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Title:

ADHESION PROMOTERS FOR SEALANTS

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Signature: Andrew M. Lawrence (Andrew M. Lawrence)

ADHESION PROMOTERS FOR SEALANTS**CROSS REFERENCE TO RELATED APPLICATIONS**

This is a continuation-in-part of U.S. Patent Application Serial No. 10/434,616,
5 filed May 9, 2003, and U.S. Patent Application Serial No. 10/435,212, filed May 9, 2003,
which are both continuation-in-parts of U.S. Patent Application Serial No. 10/301,770,
filed November 21, 2002, and U.S. Patent Application Serial No. 10/144,229, filed May
10, 2002, the entire respective disclosures of which are hereby incorporated by reference.

FIELD OF THE INVENTION

10 The present invention is directed to adhesion promoters for adhering sealants to
substrates, such as glass, metals, ceramics, cementitious materials (e.g., concrete),
asphaltic materials, and polymeric materials.

BACKGROUND OF THE INVENTION

Sealants typically have a gelatinous-type consistency which permits easy
15 application to a substrate (or between substrates). Preferably, the sealant subsequently
cures *in-situ* (i.e., where it has been applied) to form an elastomeric-type material. A
wide variety of sealants have been developed, including silicone sealants, butyl rubber
sealants, acrylic sealants, urethane sealants, and modified urethane sealants.

Such sealants generally include a polymer having a molecular weight low enough
20 for ease of application and a curing agent which causes cross-linkages to form between
the low molecular weight polymers (preferably, after application of the sealant to a
substrate), thereby resulting in the formation of a cross-linked/branched polymeric
material *in-situ*. Sealants are useful, for example, for filling openings in buildings to seal
them from the elements.

25 In order to be successful in such applications, for example, in order to form a
reliable seal, the sealant must adhere to the substrate to which it is applied. The formation
of a reliable, effective seal is especially problematic when the sealant is continuously
challenged by the elements, for example, when the sealant composition is submerged
under water. Accordingly, compositions and methods for improving the adhesion of
30 sealant compositions to a wide variety of substrates are needed. Moreover, compositions

and methods for improving the adhesion of sealant compositions which are continuously challenged by the elements are similarly needed.

SUMMARY OF THE INVENTION

In brief, it has been found that long chain esters formed by reacting mono, di-,
5 and/or tri-carboxylic acids containing one, two, or three C₆-C₂₄ long chain radicals or
fatty acid residues, and alcohols containing a C₃-C₂₄ alkyl group, when added with an
adhesive resin, such as a melamine-containing resin or a phenol-, *e.g.*, resorcinol-
containing resin, *e.g.*, a novolak resin, unexpectedly increases adhesion between a sealant,
such as silicone sealants, butyl rubber sealants, acrylic sealants, urethane sealants, and
10 modified urethane sealants, and a substrate, for example, glass substrates, metal
substrates, ceramic substrates, polymeric substrates, cementitious materials such as
concrete, asphaltic materials, and the like.

Surprisingly good adhesion between sealants and various substrates has been
obtained by adding an adhesive resin and one or more long chain mono-, di-, and/or tri-
15 esters, particularly dimerate esters reacted from C₁₈ fatty acids and C₃-C₂₄ alcohols,
preferably C₃-C₁₈ alcohols, more preferably C₆-C₁₈ alcohols. Preferably, the esters
provide unexpected, tenacious bonding between the sealants and the substrate, when
combined with an adhesive resin. It is theorized that the long chain esters of the
invention strongly adhere both to the sealant composition and to the resin, with the resin
20 providing sufficient bonding to the substrate.

Examples of suitable substrates include metal surfaces such as steel surfaces,
brass-coated steel surfaces, copper surfaces, brass surfaces and aluminum surfaces, glass
surfaces, polymeric surfaces, cementitious surfaces such as concrete, asphaltic surfaces,
and the like.

25 One aspect of the invention provides sealant compositions characterized by good
adhesion to various substrates. Another aspect of the invention provides methods of
adhering a sealant composition to a substrate.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As used herein, the term "adhesion promoter system" refers to the combination of
30 at least one long chain ester compound and at least one adhesive resin. The adhesion

promoter systems of the invention are useful for improving the adhesion of sealant compositions to various substrates, particularly ceramic substrates such as concrete. Surprisingly, the adhesion promoter systems disclosed herein significantly increase the adhesion of the sealant compositions to such substrates. In the description, the terms

5 "adhesion promoter system" and "adhesion promoter" may be used interchangeably.

As used herein, the terms "sealant" and "sealant composition" refers to a composition which can be extruded, dispensed, poured and/or otherwise applied to a substrate, and which is capable of subsequent hardening to form a permanent bond with the substrate. The sealant compositions of the invention typically comprise a sealant and

10 an adhesion promoter system, as described herein. In an alternative embodiment, the sealant compositions of the invention comprise a sealant and a long chain ester, as described herein.

The sealant typically includes a polymer having a molecular weight low enough for ease of application, and a curing agent for the polymer. Typically the sealant polymer

15 has a molecular weight between about 1000 grams/mol and about 1,000,000 grams/mol, preferably between about 2500 grams/mol and about 500,000 grams/mol, most preferably between about 5000 grams/mol and about 100,000 grams/mol.

After application of the sealant (or a sealant composition in accordance with the invention) to a substrate, the curing agent causes cross-linkages to form between the

20 polymers, typically resulting in the *in-situ* formation of a cross-linked/branched polymeric material having an elastomeric-like consistency. However, waterborne sealants can include high molecular weight polymers, which are encapsulated in emulsion form, which allows for ease of flow for application to substrates. In such an emulsion sealant, a curing agent is typically not needed for development of desired physical

25 properties.

Most sealants comprise synthetic polymers; however, sealants including natural polymers are also known. Representative synthetic sealant polymers in accordance with the invention include silicones, butyl rubbers, acrylics, urethanes, modified urethanes, and the like. Representative natural sealant polymers in accordance with the invention

30 include putty (linseed oil based), asphalt, and various conventionally known waxes.

Typical representative sealants are provided below:

1. Silicone sealants

Polymer: polydimethylsiloxane.

5 Curing agents: acetoxysilanes, methyltrimethoxysilane, N-methylacetamidossilanes, and ethylorthosilicate.

Additives: titanate catalysts, dibutyltin diacetate, and dibutyltin dilaurate.

Fillers: fumed silica, calcium carbonate, and ground silica.

Conventionally known adhesion promoters: alkoxyaminosilanes, alkoxydiamino functionalized silanes, alkoxyacetoxysilanes, epoxy functionalized silanes,
10 and isocyanurate functionalized silanes.

2. Butyl rubber sealants

Polymer: poly(isoprene-co-isobutylene-co-divinylbenzene).

Fillers: silica and carbon black.

3. Acrylic sealants

15 Polymer: poly(methyl methacrylate-co-butyl acrylate).

Fillers: calcium carbonate.

Conventionally known adhesion promoters: amino functionalized silanes.

4. Urethane sealants

20 Polymer: reaction product of an amine or alcohol functionalized polyether with a diisocyanate.

Curing agent: diisocyanates.

Additives: plasticizers, UV absorbers, dibutylphthalate, dibenzylphthalate, butylbenzylphthalate, carbon black, titanium dioxide.

Fillers: calcium carbonate.

25 Conventionally known adhesion promoters: amino functionalized silanes.

5. Modified urethane sealants

Polymer: reaction product of a polyether, a diisocyanate and an amino functionalized silane or alkoxy silane terminated polyether.

Curing agent: alkoxy functionalized silanes (methyltrimethoxysilane, etc).

Catalyst : dibutyltin dicarboxylate.

5 Fillers: calcium carbonate.

Additives :carbon black, titanium dioxide, plasticizers, UV absorbers, dibutylphthalate, dibenzylphthalate, and butylbenzylphthalate.

Conventionally known adhesion promoters: alkoxyaminosilanes, alkoxydiamino functionalized silanes, alkoxyacetoxo functionalized silanes, epoxy functionalized silanes,
10 and isocyanurate functionalized silanes.

The sealant compositions of the invention can further include additives such as solvents, plasticizers, fillers, UV stabilizers, and other, conventional adhesion promoters. For example, in sealant compositions sensitive to U.V. light, such as sealant compositions including urethane sealants, additives to block U.V. radiation, or absorb UV radiation or
15 free radicals generated by the UV radiation, are typically added. With many of the sealant compositions in accordance with the invention, conventionally known adhesion promoters are also added. Some sealant compositions contain pre-cured polymers that are swollen or dispersed in solvents. For example, sealants having large polymers, gums, waxes or pre-cured polymers dispersed in water in the form of an emulsion are known. In
20 addition to many of the above types of ingredients and additives, emulsion-based sealants (and the inventive sealant compositions containing same) typically include one or more surfactants.

The inventive sealant compositions provide excellent adhesion to ceramic, glass, metal and polymeric substrates, and can be used to seal in and around bathroom fixtures,
25 in storage areas, in vents, plumbing lines, flooring, vehicular wheel wells, sanitary and storm sewer manholes, irrigation and drainage system joints, septic tanks, underground vault seals (e.g., burial vaults), architectural foundation joints, in conjunction with o-rings (for example, in pipe joints), and the like. The sealant compositions in accordance with the invention are surprisingly weather-resistant, and therefore provide sealing and
30 bonding products capable of use in the manufacturing and maintenance of pools, spas,

vehicles and many other applications. For example, with respect to pools and spas, the sealant compositions can be used to seal joints around storage and hatch compartments, between joints on exterior substrates, and plumbing and electrical outlets. When used as a joint and gap sealant, the sealant compositions can protect these and other areas.

- 5 Moreover, upon curing, the sealant compositions have excellent elastic properties and thus provide an effective seal for long periods of time.

The term "sealant composition" typically refers to the combination of a sealant and an adhesion promoter system in accordance with the invention. Alternatively, the term "sealant composition" can refer to the combination of a sealant and a long chain
10 ester in accordance with the invention.

Typically, in the sealant compositions according to the invention, long chain esters are typically added to a sealant with an adhesive resin. According to one aspect of this embodiment, the adhesion promoter systems may be added to a sealant(s) as a liquid in order to promote adhesion of the sealant to a substrate. For example, the adhesive
15 resin(s) and long chain ester(s) are solubilized in one or more suitable organic solvents. Alternatively, the adhesive resin(s) and long chain ester(s) can be emulsified in water with one or more suitable emulsifying agents to form a water-based emulsion.

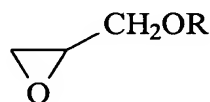
The water-based emulsions should have an HLB value of about 4 to about 5 for best ester dispersion in the emulsion. In liquid form, the adhesion promoter has a number
20 of advantages, particularly the ability to coat or pre-treat a substrate, such as a ceramic (e.g., concrete), metal or polymeric substrate, with the liquid ester/resin adhesion promoter for increased adherence of a sealant composition to the substrate. Other advantages include (1) the ability to prepare a relatively high concentration solution of the adhesion promoter, e.g., 50-90% by weight of the adhesion promoter, which can be
25 diluted upon addition to a sealant composition or upon substrate coating; (2) the ability to include excess alcohol, e.g., 2-ethylhexanol, during the synthesis of the long chain ester portion of the liquid adhesion promoter, for use as a solvent for solubilizing the resin portion of the liquid adhesion promoter. The use of excess alcohol during the synthesis of the esters is particularly advantageous for ester synthesis since the esterification reaction
30 proceeds faster with excess alcohol. Since the excess alcohol is useful in solubilizing the resin, the excess alcohol can remain with the synthesized ester without removing much,

or any, of the excess alcohol in an ester concentration or purification step. The liquid adhesion promoter, whether solubilized in an organic liquid or emulsified in a water-based emulsion, can be added directly to the sealant composition for adhesion to a substrate, *e.g.*, a metal, glass, ceramic, polymeric layer, film, or fibrous substrate, or can
 5 be used to pre-treat, *e.g.*, coat, the substrate for adhering a representative sealant thereto.

In accordance with another embodiment of the present invention, it has also been found that the addition of one or more reactive organic solvents (reactive diluents) to the sealants compositions described herein, in addition to a solvent used to solubilize the adhesive resin, or as a replacement for any portion of the resin solvent or all of the resin
 10 solvent, unexpectedly increases the adhesion of the sealant composition to various substrates such as metal surfaces, *e.g.*, steel surfaces, brass-coated steel surfaces, copper surfaces, brass surfaces and aluminum surfaces, glass surfaces, ceramic surfaces (*e.g.*, concrete surfaces), polymeric surfaces and the like.

Examples of suitable reactive diluents include (1) glycidyl ethers, (2) diglycidyl
 15 ethers; (3) aliphatic, straight chain epoxides; (4) epoxidized vegetable oils, particularly epoxidized soybean oil; (5) cycloaliphatic epoxies; (6) glycidyl esters, and (7) diglycidyl esters.

(1) Glycidyl ethers generally have a structural formula as follows:

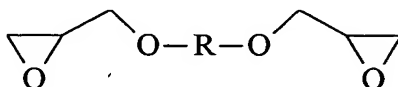


20 where R is alkyl (*e.g.*, methyl, ethyl, butyl, isobutyl, and the like), alkyl containing one or more olefinic bonds, or aryl (*e.g.*, phenyl, toluyl, benzyl, and the like). Such species include reaction products of epichlorohydrin with methanol, ethanol, isopropanol, n-butanol, 1-octanol, 2-ethylhexanol, n-decanol, isooctanol, isodecanol, oleyl alcohol, benzyl alcohol, or any other alcohol, as well as mixtures of alcohols, for example, a
 25 mixture of n-octyl and n-decyl.)

Examples include 2-ethylhexyl glycidyl ether; allyl glycidyl ether; dodecyl glycidyl ether; decyl glycidyl ether; iso-butyl glycidyl ether; n-butyl glycidyl ether; naphthyl glycidyl ether; tridecyl glycidyl ether; phenyl glycidyl ether; 2-ethylhexyl

glycidyl ether; C₈-C₁₀ aliphatic glycidyl ether; p-tertiarybutylphenyl glycidyl ether; nonylphenyl glycidyl ether; and phenyl glycidyl ether.

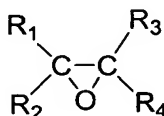
(2) Diglycidyl ethers generally have a structural formula as follows:



- 5 Where R is a straight chain or branched aliphatic moiety, for example (CH₂)_n, where n=2-10, e.g., -CH₂-CH(CH₃)CH₂-, -CH₂-C(CH₃)₂-CH₂-, and the like. These species include reaction products of epichlorohydrin with a diol or mixtures of diols, such as ethylene glycol, propylene glycol, 1,4-butylene glycol, 1,3-butylene glycol, 1,6-hexanediol, 2-methyl-1,3-propanediol, 2,2-dimethyl-1,3-propanediol, and mixtures thereof. R can also
- 10 be an aromatic moiety, resulting in an epoxy structure that is the reaction product of glycidol with common bisphenols such as bisphenol A and bisphenol F.

- Examples include 1,6-hexanediol diglycidyl ether; bisphenol A diglycidyl ether; neopentyl glycol diglycidyl ether; 1,4 butanediol diglycidyl ether; cyclohexanedimethanol diglycidyl ether; polypropylene glycol diglycidyl ether; polyethyleneglycol diglycidyl
- 15 ether; dibromoneopentyl glycol diglycidyl ether; trimethylopropane triglycidyl ether; castor oil triglycidyl ether; propoxylated glycerin triglycidyl ether; and sorbitol polyglycidyl ether.

(3) Aliphatic, straight chain epoxides have a general structural formula as follows:



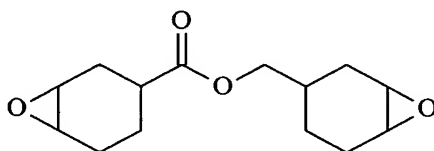
Examples include propylene oxide, butylene oxide, as well as the following:

	R ₁	R ₂	R ₃	R ₄
	CH ₂ =CH	H	H	H
	C ₃ H ₇	H	H	H
25	(CH ₃) ₂ CH	H	H	H
	C ₅ H ₁₁	H	H	H
	C ₆ H ₁₃	H	H	H
	(CH ₃) ₂ CH(CH ₂) ₃	H	H	H
	C ₈ H ₁₇	H	H	H
30	C ₁₆ H ₃₃	H	H	H
	C ₁₈ H ₃₇	H	H	H
	C ₆ H ₅	H	H	H

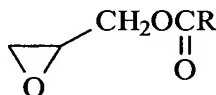
	<u>R₁</u>	<u>R₂</u>	<u>R₃</u>	<u>R₄</u>
	C ₆ H ₅ CH ₂	H	H	H
	C ₆ H ₅ (CH ₂) ₂	H	H	H
	C ₆ H ₅ (CH ₂) ₃	H	H	H
5	C ₆ H ₅ (CH ₂) ₄	H	H	H
	CH ₂ OH	H	H	H
	CH ₃ OCH ₂	H	H	H
	C ₂ H ₅ OCH ₂	H	H	H
	C ₃ H ₇ CHOH	H	H	H
10	C ₆ H ₅ OCH ₂	H	H	H
	CH ₃ CO ₂ CH ₂	H	H	H
	CH ₂ =CHCO ₂ CH ₂	H	H	H
	CH ₂ =C(CH ₃)-CO ₂ CH ₂	H	H	H
	CH ₃ CH=CH-CO ₂ CH ₇	H	H	H
15	Br	H	H	H
	CH ₂ F	H	H	H
	CH ₂ Cl	H	H	H
	CH ₂ Br	H	H	H
	CH ₂ I	H	H	H
20	CF ₃	H	H	H
	CCl ₃	H	H	H
	(C ₂ H ₅) ₂ NCH ₂	H	H	H
	C ₂ H ₅	H	C ₂ H ₅	H
25	C ₂ H ₅	H	CF ₃	H
	C ₂ H ₅	H	C ₃ F ₇	H
	C ₄ H ₉	H	CH ₂ Br	H
	C ₅ H ₁₁	H	Cl	H
	C ₆ H ₅	H	CH ₃	H
30	C ₆ H ₅	H	C ₂ H ₅	H
	C ₆ H ₅	H	C ₃ H ₇	H
	C ₆ H ₅	H	C ₃ H ₇ (iso)	H
	C ₆ H ₅	H	C ₆ H ₅ CH ₂	H
	CF ₃	H	F	H
35	CH ₃	CH ₃	CH ₃	H
	CH ₃	C ₂ H ₅	CH ₃	H
	CH ₃	CH ₃	C ₃ F ₇	H
	CH ₃	CH ₃	CO ₂ C ₂ H ₅	H
	CH ₃	CF ₃	Cl	H
	C ₂ H ₅	C ₂ H ₅	OH ₃	H
40	CH ₃	CH ₃	CH ₃	CH ₃
	CH ₃	CH ₃	H	H
	CH ₃	CF ₃	H	H
	CH ₃	C ₂ H ₅	H	H
	CH ₃	C ₃ F ₇	H	H
45	C ₂ H ₅	CH ₂ Br	H	H
	C ₆ H ₅	CH ₃	H	H
	C ₆ H ₅ (CH ₂) ₃	CH ₃	H	H
	C ₆ H ₅	OH	H	H
50	Cl	Cl	H	H
	CH ₃	H	CH ₃ (cis)	H
	CH ₃	H	H	CH ₃ (trans)
	CH ₃	H	C ₂ H ₅ (cis)	H
	CH ₃	H	H	C ₂ H ₆ (trans)
55	CH ₃	H	C ₃ H ₇	H
	CH ₃	H	C ₃ H ₇ (iso)	H
	CH ₃	H	CF ₃	H
	CH ₃	H	CH ₂ Br	H
	CH ₃	H	C ₃ F ₇	H
60	CH ₃	H	CO ₂ H	H

(4) Epoxidized oils such as epoxidized soybean oil, epoxidized linseed oil, epoxidized safflower oil, epoxidized corn oil, epoxidized cottonseed oil, epoxidized rapeseed oil, epoxidized peanut oil, and other similar species derived from the epoxidation of C₁₈-unsaturated esters of glycerin can also be used as the reactive diluent.

- 5 (5) Cycloaliphatic epoxides, such as 1,2-cyclohexene oxide, 1,2-cyclopentene oxide, 1,2,3,4,-diepoxybutene, vinylcyclohexene dioxide, and the like, as well as those products marketed by Shell Oil under the brand name EPON[®], an example of which is shown below.



- 10 (6) Glycidyl esters generally have a structural formula as follows:

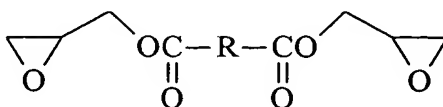


Where R is a straight chain aliphatic, such as $-(CH_2)_n-CH_3$ (wherein $n=1-9$) or branched aliphatic such as $-CH_2CH(CH_3)_2$, $-CH(CH_2CH_3)(CH_2)_4CH_3$, and the like. R can also be contain one or more olefinic bonds. R can also be aromatic, i.e., -phenyl or -toluyl.

- 15 These glycidyl esters include reaction products of glycidol with carboxylic acids, such as acetic acid, propionic acid, isobutyric acid, 2-ethylhexoic acid, benzoic acid, toluic acid (various isomers), oleic acid, linoleic acid, linolenic acid, as well as mixtures of carboxylic acids. Preferably, the reaction with glycidol is with the methyl esters of the carboxylic acids (e.g., trans-esterification).

- 20 Examples include glycidyl neodecanoate; acetic acid glycidyl ester; butyric acid glycidyl ester; propionic acid glycidyl ester; valeric acid glycidyl ester; caproic acid glycidyl ester; capric acid glycidyl ester; caprylic acid glycidyl ester; lauric acid glycidyl ester; and glycidyl ester of linoleic acid or of linolenic acid.

(7) Diglycidyl esters generally have a structural formula as follows:



Where R is straight chain aliphatic $-(CH_2)_n$ wherein n is typically between 1 and 8, or branched aliphatic, or aliphatic/cycloaliphatic mixed, or aliphatic containing one or more olefinic bonds. R can also be aromatic. These diglycidyl esters include reaction products of glycidol with dicarboxylic acids such as malonic acid, glutaric acid, adipic acid, azelaic acid, sebacic acid, phthalic anhydride, isophthalic acid, terephthalic acid, and one or more dimer acids. Preferably, the reaction with glycidol is with the methyl esters of the carboxylic acids (e.g., trans-esterification).

In the reactive diluent embodiment described herein, the reactive diluent is typically included in an amount between about 0.5% and about 50% by weight, usually between about 5 wt.% and about 40 wt.%, and most preferably between about 10 wt.% and about 30 wt.%, based on the total weight of adhesion promoter (i.e., adhesive resin plus ester) in the composition. These reactive diluents function as solvents to compatibilize the sealant(s), adhesive resin, and long chain ester compositions described herein, and are believed to participate chemically in the adhesion of the sealant composition to the substrates described herein.

In another embodiment, the substrate can be pretreated with the adhesive resin component of the adhesion promoter system. The resin-treated substrate can subsequently be treated with the ester component of the adhesion promoter system for improved adherence of a sealant to a substrate. The resin-treated substrate can be ester treated in any manner, preferably by dipping or coating the resin-treated substrate with an organic solution of the ester or a water-based emulsion containing the ester.

Alternatively, the ester component can be added to a sealant, for subsequent interaction with the resin treated substrate. According to this embodiment of the invention, the term "sealant composition" refers to a combination of a sealant and an ester having Formulas I, II, III, IV, and combinations thereof.

The adhesion promoter systems can also be mixed with a preferably inert, dry carrier, such as calcium silicate, to form an alternative delivery system, which can be

incorporated into the sealant composition(s). In such systems, the dry, inert carrier facilitates delivery of the active adhesion promoting agents to the sealant(s) of the sealant composition.

For example, a representative adhesion promoter system utilizing a dry carrier,
5 RX-13845, was prepared by adding preheated Cyrez CRA 138 resin liquid to a dry carrier contained in a mixing bowl, followed by addition of preheated RX-13804, a representative long chain ester in accordance with the invention. The materials were mixed at low speed for about 3 minutes. The materials were blended for an additional time period, approximately 3 minutes. RX-13845 is advantageous in that it permits
10 liquids to be handled as powders. Because the active adhesion promoter is released from the carrier, incorporation of RX-13845 into a sealant composition allows the adhesion promoter to function in the same manner as if it had been incorporated into the sealant composition as a neat material.

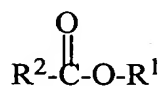
In yet another refinement of the invention, the adhesion promoters may be
15 formulated as a "polymer masterbatch." According to this aspect of the invention, a pellet comprising a masterbatch polymer (about 6 wt.% to about 20 wt.%), a filler or other similar inert ingredients (about 0 wt.% to about 14 wt.%), with the balance being an adhesion promoter system (*i.e.*, at least one ester compound in accordance with formulas I-IV and at least one adhesive resin such as melamine) is added to a sealant to improve
20 adhesion of the formed sealant composition to a substrate. Typically, the masterbatch polymer and the initial polymeric component of the sealant to which the masterbatch polymer is added are miscible. Preferably, the masterbatch polymer and the initial polymeric component of the sealant are the same.

Throughout the specification, the adhesion promoter systems are generally used in
25 an amount between about 0.2% by weight and about 30% by weight, based on the weight of the sealant(s) in the sealant composition(s). Typically, the ester and adhesive resin components of an adhesion promoter system of the invention are both present in an amount between about 0.1% and about 15% by weight, usually between about 1 wt.% and about 10 wt.%, and most preferably between about 2 wt.% and about 8 wt.%, based on
30 the weight of the sealant(s) in the sealant composition.

Ranges may be expressed herein as from "about" or "approximately" one particular value to "about" or "approximately" another particular value. When such a range is expressed, another embodiment includes the range from the one particular value to the other particular value. Similarly, when numerical values are expressed as approximations, *e.g.*, by use of the antecedent "about," it will be understood that the particular value forms another embodiment.

The long chain esters may be monoesters, diesters, triesters, or mixtures thereof, that may include saturated or unsaturated hydrocarbon chains, straight chain or branched, having none, one, two or three double bonds in the hydrocarbon chains.

The monoesters have a formula I, as follows:

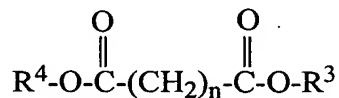


(I)

wherein R^1 is a $\text{C}_3\text{-C}_{24}$ alkyl, preferably $\text{C}_3\text{-C}_{18}$ alkyl, more preferably $\text{C}_6\text{-C}_{18}$ alkyl, straight chain or branched, saturated or unsaturated containing 1 to 3 carbon-to-carbon double bonds; and,

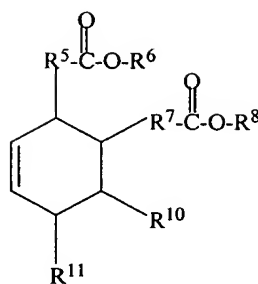
R^2 is a $\text{C}_3\text{-C}_{24}$ hydrocarbon, preferably $\text{C}_6\text{-C}_{24}$ hydrocarbon, more preferably $\text{C}_8\text{-C}_{18}$ hydrocarbon, saturated or unsaturated having 1 to 6, preferably 1 to 3 carbon-to-carbon double bonds.

The diesters have a formula II or III, as follows:



(II)

wherein $n=3\text{-}24$, preferably $6\text{-}18$, and more preferably $3\text{-}10$, and R^3 and R^4 , same or different, are $\text{C}_3\text{-C}_{24}$ alkyl, preferably $\text{C}_3\text{-C}_{18}$ alkyl, more preferably $\text{C}_6\text{-C}_{18}$ alkyl, straight chain or branched, saturated or unsaturated containing 1 to 3 carbon-to-carbon double bonds.



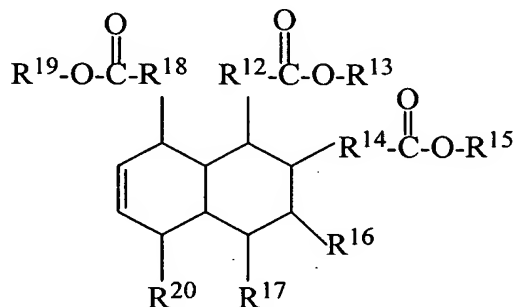
(III)

wherein R^5 and R^7 , same or different, are C_3 - C_{24} alkyl, preferably C_6 - C_{24} alkyl, more preferably C_8 - C_{18} alkyl, straight chain or branched, either saturated or containing 1 to 6, preferably 1 to 3 carbon-to-carbon double bonds;

- 5 R^6 and R^8 , same or different, are C_3 - C_{24} alkyl, preferably C_3 - C_{18} alkyl, more preferably C_6 - C_{18} alkyl, straight chain or branched, saturated or unsaturated containing 1 to 3 carbon-to-carbon double bonds; and

- 10 R^{10} and R^{11} , same or different, are C_3 - C_{24} saturated hydrocarbon chains, preferably C_3 - C_{18} saturated hydrocarbon chains, more preferably C_6 - C_{18} saturated hydrocarbon chains, straight chain or branched; or unsaturated C_3 - C_{24} hydrocarbon chains, preferably C_3 - C_{18} unsaturated hydrocarbon chains, more preferably C_6 - C_{18} unsaturated hydrocarbon chains, straight chain or branched, containing 1 to 6, preferably 1 to 3 carbon-to-carbon double bonds.

The triesters have a formula IV, as follows:



(IV)

wherein R^{12} , R^{14} and R^{18} , same or different, are C_3 - C_{24} alkyl, preferably C_6 - C_{24} alkyl, more preferably C_8 - C_{18} alkyl, straight chain or branched, either saturated or containing 1 to 6, preferably 1 to 3 carbon-to-carbon double bonds;

R^{13} , R^{15} and R^{19} , same or different, are C_3 - C_{24} alkyl, preferably C_3 - C_{18} alkyl, more preferably C_6 - C_{18} alkyl, straight chain or branched, saturated or unsaturated containing 1 to 3 carbon-to-carbon double bonds; and

R^{16} , R^{17} and R^{20} , same or different, are C_3 - C_{24} saturated hydrocarbon chains, preferably C_3 - C_{18} saturated hydrocarbon chains, more preferably C_6 - C_{18} saturated hydrocarbon chains, straight chain or branched; or unsaturated C_3 - C_{24} hydrocarbon chains, preferably C_3 - C_{18} unsaturated hydrocarbon chains, more preferably C_6 - C_{18} unsaturated hydrocarbon chains, straight chain or branched, containing 1 to 6, preferably 1 to 3 carbon-to-carbon double bonds.

10 The fatty acid residues or hydrocarbon chains R^2 , R^5 , R^7 , R^{12} , R^{14} and R^{18} of the esters of formulas I, II, III, and IV can be any C_3 - C_{24} hydrocarbon chain, preferably any C_6 - C_{24} hydrocarbon chain, more preferably any C_8 - C_{18} hydrocarbon chain, either saturated or containing 1 to 6, preferably 1 to 3 carbon-to-carbon double bonds, and can be derived from animal or vegetable fatty acids such as butter; lard; tallow; grease;

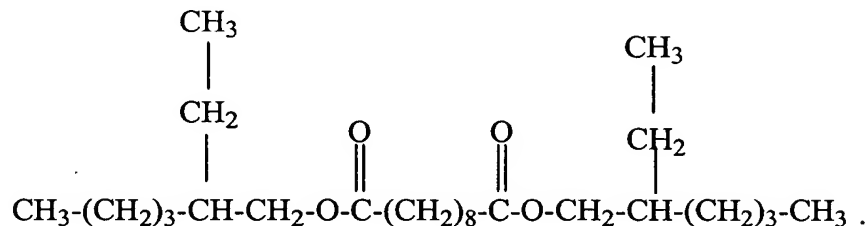
15 herring; menhaden; pilchard; sardine; babassu; castor; coconut; corn; cottonseed; jojoba; linseed; oiticica; olive; palm; palm kernel; peanut; rapeseed; safflower; soya; sunflower; tall; and/or tung. Examples are the hydrocarbon chain residues from the following fatty acids, where the number in parentheses indicates the number of carbon atoms, and the number of double bonds, *e.g.*, (C_{24-6}) indicates a hydrocarbon chain having 24 carbon

20 atoms and 6 double bonds: Hexanoic (C_{6-0}); Octanoic (C_{8-0}); Decanoic (C_{10-0}); Dodecanoic (C_{12-0}); 9-Dodecenoic (CIS) (C_{12-1}); Tetradecanoic (C_{14-0}); 9-Tetradecenoic (CIS) (C_{14-1}); Hexadecanoic (CIS) (C_{16-0}); 9-Hexadecenoic (CIS) (C_{16-1}); Octadecanoic (C_{18-0}); 9-Octadecenoic (CIS) (C_{18-1}); 9-Octadecenoic, 12-Hydroxy-(CIS) (C_{18-2}); 9, 12-Octadecadienoic (CIS, CIS) (C_{18-2}); 9, 12, 15 Octadecatrienoic (CIS, CIS, CIS) (C_{18-3}); 9,

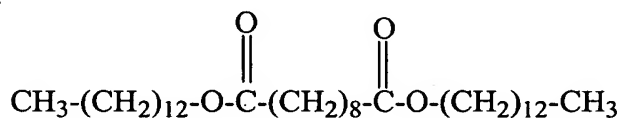
25 11, 13 Octadecatrienoic (CIS, TRANS, TRANS) (C_{18-3}); 9, 11, 13 Octadecatrienoic, 4-Oxo (CIS, TRANS, TRANS) (C_{18-4}); Eicosanoic (C_{20}); 11-Eicosenoic (CIS) (C_{20-1}); Eicosadienoic (C_{20-2}); Eicosatrienoic (C_{20-3}); 5, 8, 11, 14 Eicosatetraenoic (C_{20-4}); Eicosapentaenoic (C_{20-5}); Docosanoic (C_{22}); 13 Docosenoic (CIS) (C_{22-1}); Docosatetraenoic (C_{22-4}); 4, 8, 12, 15, 19 Docosapentaenoic (C_{22-5});

30 Docosahexaenoic (C_{22-6}); Tetracosenoic (C_{24-1}); and 4, 8, 12, 15, 18, 21 Tetracosahexaenoic (C_{24-6}).

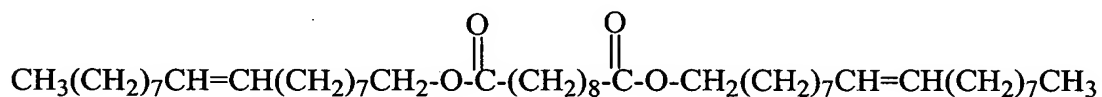
Examples of particularly useful diesters of formula II include a saturated diester formed by the reaction of sebacic acid and 2-ethylhexyl alcohol:



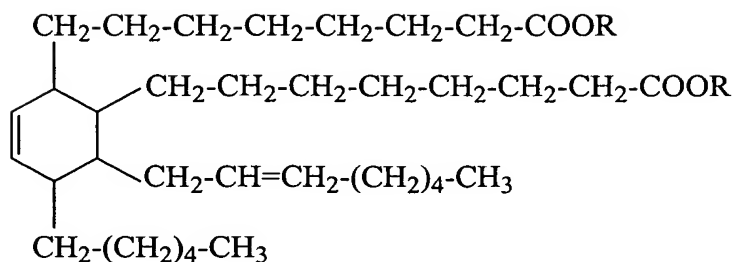
- Other useful diesters falling within formula II include the saturated diester formed
 5 by the reaction of sebacic acid with tridecyl alcohol,



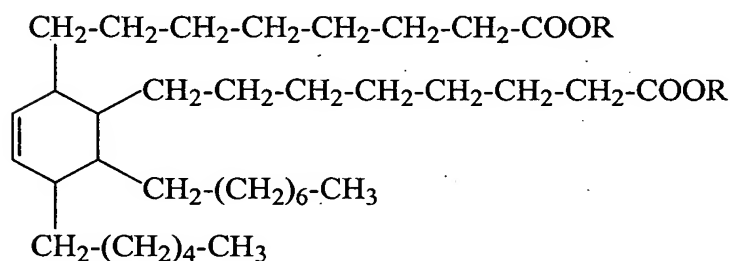
and the unsaturated diester formed by reaction of sebacic alcohol with oleyl alcohol:



- 10 Useful cyclic diesters falling within formula III include dimerate ester structures formed by the reaction of a C₃₆ dimer acid derived from tall oil fatty acids and C₃-C₂₄, preferably C₃-C₁₈, more preferably C₆-C₁₈ alcohol, straight chain or branched, saturated or unsaturated containing 1 to 3 carbon-to-carbon double bonds. Examples of such cyclic esters include the following structures, wherein the dimer acid corresponding to structure
 15 A is formed by self reaction of linoleic acid, the dimer acid corresponding to structure B is formed by reacting linoleic acid with oleic acid, and the dimer acid corresponding to structure C is formed by reacting linoleic acid with linolenic acid:

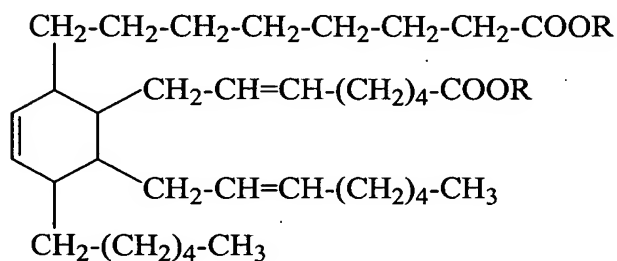


(A);



(B);

and

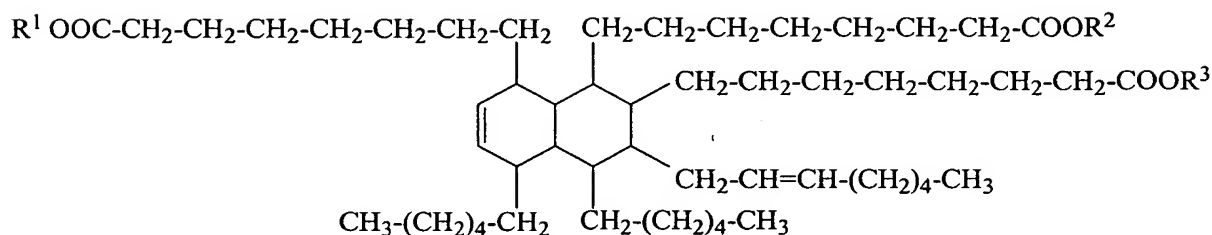


(C);

wherein each R, same or different, in formulas (A), (B), and (C) is a C₃-C₂₄ alkyl, preferably C₃-C₁₈ alkyl, more preferably C₆-C₁₈ alkyl, straight chain or branched, saturated or unsaturated containing 1 to 3 carbon-to-carbon double bonds. Another

- 5 example of a useful unsaturated diester (dimerate ester) is formed by the reaction of a predominantly C₃₆ dimer acid reacted with 2-ethylhexyl alcohol. An additional useful unsaturated diester (dimerate ester) is formed by the reaction of a predominantly C₃₆ dimer acid with tridecyl alcohol.

- 10 A representative example of the triester (trimerate ester) of formula IV is the following structure (D):



(D);

wherein each R^1 , R^2 , and R^3 , same or different, is a $\text{C}_3\text{-C}_{24}$ radical, preferably $\text{C}_3\text{-C}_{18}$, more preferably $\text{C}_6\text{-C}_{18}$, straight chain, or branched, saturated or unsaturated containing 1 to 3 carbon-to-carbon double bonds.

A particularly useful blend of long chain esters is formed from blends of mono, dimer, and trimer acids, for example, products having CAS# 61788-89-4. Esters prepared from such products are blends including, primarily, the above C_{36} and C_{54} dimerate and trimerate esters (A), (B), (C) and (D), shown in the above structures, that is predominantly (more than 50% by weight) the C_{36} dimerate esters (A), (B) and (C).

Commercially available blends of useful polybasic acids that can be reacted with $\text{C}_3\text{-C}_{24}$, preferably $\text{C}_3\text{-C}_{18}$, more preferably $\text{C}_6\text{-C}_{18}$ alcohols, straight chain or branched, saturated or unsaturated containing 1 to 3 carbon-to-carbon double bonds to produce the dimerate and trimerate esters, as blends, include the following: EMPOL[®] 1010 Dimer Acid; EMPOL[®] 1014 Dimer Acid; EMPOL[®] 1016 Dimer Acid; EMPOL[®] 1018 Dimer Acid; EMPOL[®] 1022 Dimer Acid; EMPOL[®] 1024 Dimer Acid; EMPOL[®] 1040 Trimer Acid; EMPOL[®] 1041 Trimer Acid; EMPOL[®] 1052 Polybasic Acid; and similar PRIPOL[™] products from Uniqema as well as UNIDYME[®] products from Arizona Chemical.

Particularly useful long chain ester additives are made by reacting any of the long chain mono, dimer and/or trimer acids with one or more straight chain or branched $\text{C}_3\text{-C}_{24}$, preferably $\text{C}_3\text{-C}_{18}$, more preferably $\text{C}_6\text{-C}_{18}$ alcohols to produce the esters of formulas I, II, III and IV. The above dimer, trimer, and polybasic acids are produced by dimerizing, trimerizing, and polymerizing (oligomerizing) long chain carboxylic acids, particularly from the above-mentioned tall oil fatty acids. Tall oil fatty acids are often

mixtures. Accordingly, the dimer acid produced by dimerizing a C₁₈ carboxylic acid (typically, a mixture of stearic, oleic, linoleic, and linolenic), after esterification, typically provides a blend of numerous dimerate and trimerate esters in accordance with formulas III and IV, including saturated and unsaturated esters (*i.e.*, some long chain esters may contain hydrocarbon chains having 1 to 6, generally 1 to 3, carbon-to-carbon double bonds). Any one, or any blend, of the esters of formulas I, II, III and/or IV, when combined with an adhesive resin, will function to increase the adhesion of a sealant composition in accordance with the invention to substrates such as ceramic substrates (e.g., concrete), glass substrates, metal substrates such as metal flat stock materials, polymeric substrates including substrates comprising natural and/or synthetic rubbers and substrates comprising thermoplastic polymeric materials.

Ceramic substrates include silicon, silicon oxide, and/or complex compounds conventionally known as silicates. Suitable ceramic substrates include structural clay products such as bricks and tiles, whitewares such as dinnerware and porcelain, all types of glass products, porcelain enamels, products including Portland cement, lime, plaster, and/or gypsum, abrasive materials such as fused silica and silicon carbide, and aluminum silicate fibers.

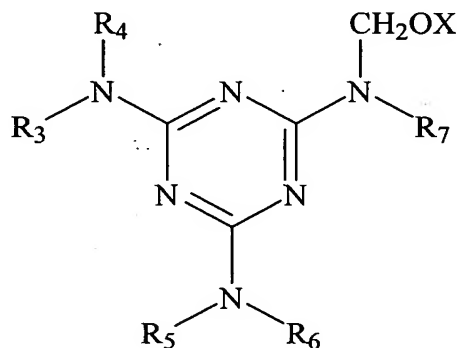
Suitable substrates comprising synthetic rubbers include homopolymers of conjugated diene compounds, such as isoprene, butadiene, chloroprene and the like, for example, polyisoprene rubber (IR), polybutadiene rubber (BR), polychloroprene rubber and the like; copolymers of the above described conjugated diene compounds with vinyl compounds, such as styrene, acrylonitrile, vinyl pyridine, acrylic acid, methacrylic acid, alkyl acrylates, alkyl methacrylates and the like, for example, styrene-butadiene copolymeric rubber (SBR), vinylpyridine-butadiene-styrene copolymeric rubber, acrylonitrile-butadiene copolymeric rubber, acrylic acid-butadiene copolymeric rubber, methacrylic acid-butadiene copolymeric rubber, methyl acrylate-butadiene copolymeric rubber, methyl methacrylate-butadiene copolymeric rubber, acrylonitrile-butadiene-styrene terpolymer, and the like; copolymers of olefins, such as ethylene, propylene, isobutylene and the like with dienes, for example isobutylene-isoprene copolymeric rubber (IIR); copolymers of olefins with non-conjugated dienes (EPDM), for example, ethylene-propylene-cyclopentadiene terpolymer, ethylene-propylene-5-ethylidene-2-

norbornene terpolymer and ethylene-propylene-1,4-hexadiene terpolymer; polyalkenamer obtained by ring opening polymerization of cycloolefins, for example, polypentenamer; rubbers obtained by ring opening polymerization of oxirane ring, for example, polyepichlorohydrin rubber and polypropylene oxide rubber which can be vulcanized with sulfur, silicone rubbers, and the like. Furthermore, halides of the above-described various rubbers, for example, chlorinated isobutylene-isoprene copolymeric rubber (CI-IIR), brominated isobutylene-isoprene copolymeric rubber (Br-IIR), fluorinated polyethylene, and the like are included. Of course, the adhesion promoters of the invention can be used to adhere sealant compositions to other rubbers. All these rubbers may be kneaded with compounding agents conventionally used for compounding with rubber, for example, fillers, such as carbon black, silica, calcium carbonate, lignin and the like, softening agents, such as mineral oils, vegetable oils, prior to vulcanization and then vulcanized.

Suitable substrates can also comprise thermoplastic polymeric materials. Such materials generally include synthetic high polymers that soften when exposed to heat and return to their original state when cooled to room temperature. More specifically, sealant compositions in accordance with the invention can be adhered to various thermoplastic polymeric material substrates using the adhesion promoter systems described herein, including substrates comprising polyvinyl chloride, nylons, propylene/ α -olefin copolymers, polyolefins such as polyethylene and polypropylene, substituted polyolefins such as polyvinylidene fluoride, ethylene/ α -olefin copolymers such as, for example, ethylene/propylene copolymers and ethylene/1-octene copolymers, polyurethane prepolymers, polystyrenes such as styrene/ethylene block copolymers, hydrogenated styrene/butadiene block copolymers, and acrylonitrile/butadiene/styrene terpolymers (ABS), cellulosic resins, acrylic resins, and combinations thereof. Other suitable polymeric substrates include thermosetting resins such as phenol/formaldehyde, melamine/formaldehyde, and the like.

The adhesion promoters include an adhesive resin, which preferably is a condensation product of a formaldehyde or methylene donor and a formaldehyde or methylene acceptor, either pre-condensed, or condensed *in-situ* while in the sealant composition. The term "methylene donor" is intended to mean a compound capable of

Examples of methylene donors which are suitable for use in the sealant compositions disclosed herein include melamine, hexamethylenetetramine, hexaethoxymethylmelamine, hexamethoxymethylmelamine, lauryloxymethyl-pyridinium chloride, ethoxy-methylpyridinium chloride, trioxan hexamethoxy-methylmelamine, the hydroxy groups of which may be esterified or partly esterified, and polymers of formaldehyde, such as paraformaldehyde. In addition, the methylene donors may be N-substituted oxymethylmelamines, of the general formula:

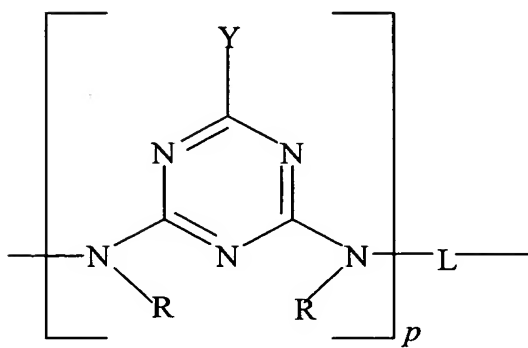
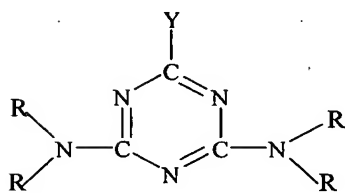
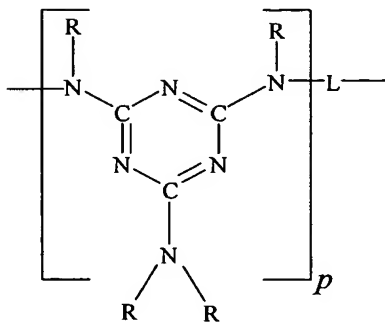
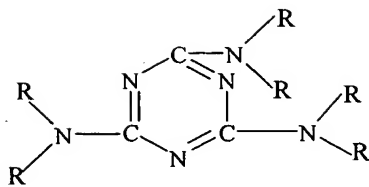


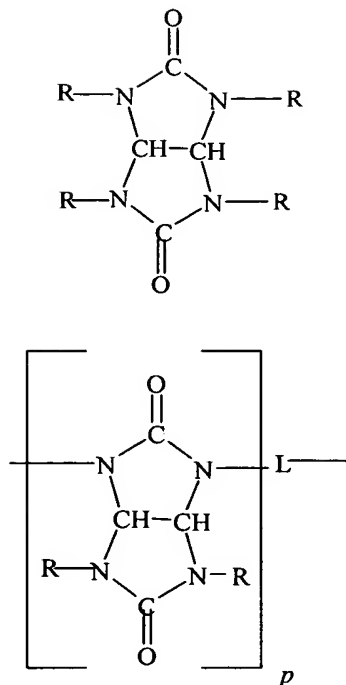
The amount of methylene donor and methylene acceptor, pre-condensed or condensed *in-situ*, that are present in the sealant composition may vary. Typically, the

amount of pre-condensed methylene donor and methylene acceptor is present will range from about 0.1 wt.% to about 15.0 wt.%; or each can be added separately in an amount of about 1 wt.% to about 10.0 wt.%, based on the weight of sealant in the sealant composition. Preferably, the amount of each of a methylene donor and methylene
5 acceptor added for *in-situ* condensation ranges from about 2.0 wt.% to about 8.0 wt.%, based on the weight of sealant in the sealant composition. The weight ratio of methylene donor to the methylene acceptor may vary. Generally speaking, the weight ratio will range from about 1:10 to about 10:1. Preferably, the weight ratio ranges from about 1:3 to 3:1.

10 Resorcinol-free adhesive resins also are useful in the sealant compositions described herein. For example, resorcinol-free adhesive resins and adhesive compounds useful in the adhesion promoter systems (*i.e.*, when combined with the long chain esters described herein) include those described in U.S. Patent Nos. 5,891,938 and 5,298,539,
both hereby incorporated by reference. The '938 patent discloses a self-condensing
15 alkylated triazine resin having high imino and/or methylol functionality. U.S. Patent No. 5,298,539 discloses additives which are substituted derivatives based on cyclic nitrogen compounds such as melamine, acetoguanamine, cyclohexylguanamine, benzoguanamine, and similar alkyl, aryl or aralkyl substituted melamines, glycoluril and oligomers of these compounds. In particular, the adhesive resins and adhesive compounds which are useful
20 as the adhesive resins in the sealant compositions described herein include the following: adhesive resins selected from the group consisting of derivatives of melamine, acetoguanamine, benzoguanamine, cyclohexylguanamine and glycoluril monomers and oligomers of these monomers, which have been substituted on average at two or more positions on the monomer or on each unit of the oligomer with vinyl terminated radicals,
25 the sealant composition being free of resorcinol; and, these derivatives which have been further substituted on average at one or more positions with a radical which comprises carbamylmethyl or amidomethyl.

Further, the adhesive resin can be any of the compounds of the following formulas:





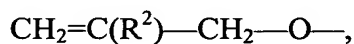
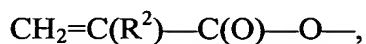
and positional isomers thereof,

wherein, in each monomer and in each polymerized unit of the oligomers, Y is selected
 5 from methyl, phenyl and cyclohexyl, and, on average,

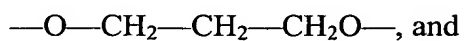
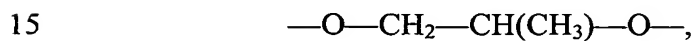
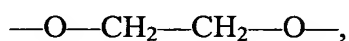
at least two R are $-\text{CH}_2-\text{R}^1$,

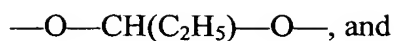
and any remaining R are H, and

at least 2 R^1 are radicals selected from:

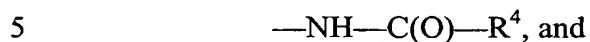
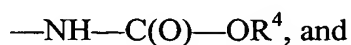
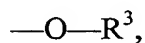


wherein R^2 is hydrogen or $\text{C}_1\text{-C}_{18}$ alkyl, and Z is a radical selected from:





any remaining R^1 radicals are selected from

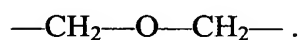


wherein R_3 is hydrogen or R_4 , and

R_4 is a $\text{C}_1\text{—C}_{18}$ alkyl, alicyclic, hydroxyalkyl, alkoxyalkyl or aromatic radical, and
in the oligomers,

P is 2 to about 10, and

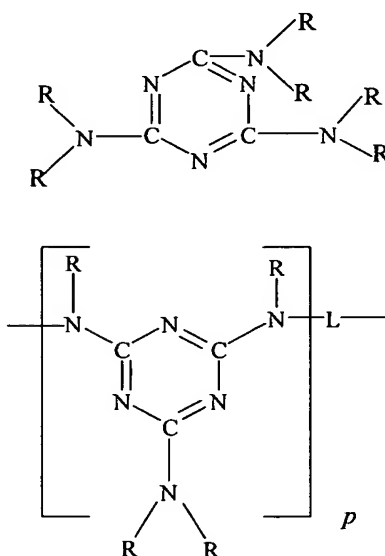
10 L is methylene or the radical



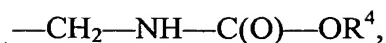
These adhesive compounds are particularly useful, wherein on average at least one R^1 in each monomer or in each oligomerized unit is —NH—C(O)—OR^4 ,

particularly the compounds of the following formulas:

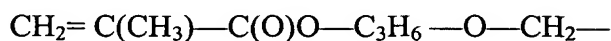
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Particularly useful adhesive resins include the above formulas wherein on average, at least one R radical in each monomer or in each oligomerized unit is

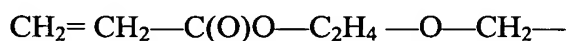


wherein R^4 is a C_1 - C_{18} alkyl, alicyclic, hydroxyalkyl, alkoxyalkyl or aromatic radical, and wherein, on average, at least two R radicals are selected from

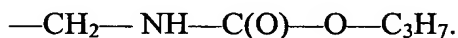


5

and



and at least one R radical is selected from



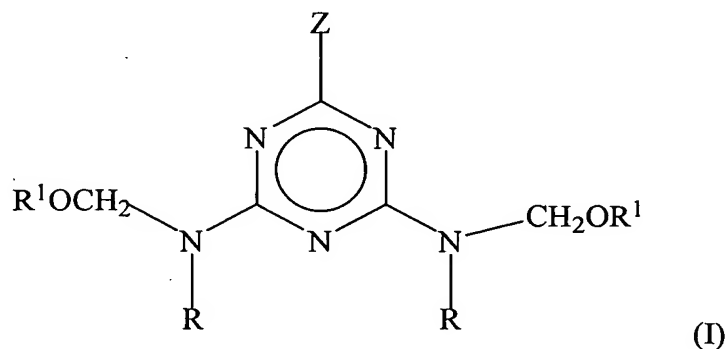
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These adhesive resins and compounds can include additional additives, particularly those selected from hydroxymethylated and alkoxyethylated (alkoxy having 1-5 carbon atoms) derivatives of melamine, acetoguanamine, benzoguanamine, cyclohexylguanamine and glycoluril and their oligomers.

15

Additional adhesive resins useful in the sealant compositions described herein include self-condensing alkylated triazine resins selected from the group consisting of (i), (ii), and (iii):

(i) a self-condensing alkylated triazine resin having at least one of imino or methylol functionality and represented by the formula (I)



20

(ii) an oligomer of (i), or

(iii) a mixture of (i) and (ii), wherein

Z is $-N(R)(CH_2OR^1)$, aryl having 6 to 10 carbon atoms, alkyl having 1 to 20 carbon atoms or an acetyl group,

each R is independently hydrogen or $-CH_2OR^1$, and

each R^1 is independently hydrogen or an alkyl group having 1 to 12 carbon atoms,

5 provided that at least one R is hydrogen or $-CH_2OH$ and at least one R^1 is selected from the alkyl group; and

wherein the sealant composition is substantially free of methylene acceptor coreactants.

10 These adhesive resins are particularly useful wherein at least one R group is hydrogen and/or wherein at least one R^1 group is a lower alkyl group having 1 to 6 carbon atoms, particularly where the adhesive resin is a derivative of melamine, benzoguanamine, cyclohexylguanamine, or acetoguanamine, or an oligomer thereof.

One particularly useful alkylated triazine adhesive resin of the above formula is wherein Z is $-N(R)(CH_2OR^1)$.

15 Another manner of eliminating resorcinol in an adhesive resin for sealant compositions disclosed herein, is to use N-(substituted oxymethyl)melamine and at least one of α - or β -naphthol. This adhesive resin employs the monohydric phenols, α - or β -naphthol, as methylene acceptors in the resin forming reaction in the absence of resorcinol.

20 Other adhesive resins useful in the sealant compositions described herein include special latices such as, for example, a vinyl-pyridine latex (VP latex) which is a copolymer of about 70 wt.% butadiene, about 15 wt.% styrene and about 15 wt.% 2-vinylpyridine; acrylonitrile rubber latices; and styrene-butadiene rubber latices. These can be used as such or in combination with one another. Another suitable adhesive resin
25 useful herein, particularly for polyesters, are those which are applied in multi-stage processes, for instance a blocked isocyanate being applied in combination with polyepoxide and the material then being treated using customary resorcinol-formaldehyde resins (RFL dip). Additional useful adhesive resins include combinations of RFL dips with other adhesion-promoting substances such as, for example, a reaction product of

trialllyl cyanurate, resorcinol and formaldehyde or p-chlorophenol, resorcinol and formaldehyde.

Other suitable adhesive resins include polyurethane resins, epoxy resins, phenol aldehyde resins, polyhydric phenol aldehyde resins, phenol furfural resins, xylene
5 aldehyde resins, urea formaldehyde resins, melamine formaldehyde resins, alkyd resins, polyester resins, and the like.

Typically, in the adhesion promoter systems, at least one ester compound in accordance with formulas I-IV is combined with an adhesive resin in a weight ratio between about 10 parts ester to about 1 part adhesive resin (*i.e.*, a ratio of about 10:1,
10 ester to resin, respectively) and about 1 part ester to about 10 parts resin (*i.e.*, a ratio of about 1:10, ester to resin, respectively). More preferably, the esters are combined with an adhesive resin in a weight ratio between about 4 parts ester to about 1 part adhesive resin and about 1 part ester to about 4 parts resin. Most preferably, the ratio of ester to adhesive resin is approximately one to one.

15 As previously described, the adhesion promoter systems can be used to adhere sealant compositions to various substrates. The sealant compositions described herein are characterized in that the surfaces of the sealant compositions are improved to provide a high adhering ability to various substrates.

The sealants and sealant compositions described herein can be compounded by
20 methods generally known, such as mixing the sealants and/or sealant compositions with various commonly used additive materials such as, for example, processing additives, such as oils, resins including tackifying resins and plasticizers, fillers, pigments, fatty acids, waxes and antioxidants.

As previously described, the sealant compositions of the invention can be used in
25 numerous applications, including bonding concrete dividers, e.g., a composite structure including first and second concrete dividers, and a sealant composition in accordance with the invention therebetween. The adhesion promoters described herein are very effective in promoting bonding between sealant compositions and concrete substrates, where conventional adhesive pretreatment has been largely ineffective. For example, the

adhesion promoter systems can be used to provide unexpectedly strong binding between a silicone sealant composition in accordance with the invention and a concrete substrate.

The invention may be better understood by reference to the following examples in which parts and percentages are by weight unless otherwise indicated.

5

EXAMPLES

Table I compares the effectiveness of sealant compositions in accordance with the invention (i.e., including adhesion promoter systems, here the exemplified adhesion promoter systems comprise dimerate esters) in promoting adhesion to various substrates with conventional sealants. More specifically, representative adhesion
10 promoters were evaluated for promoting the adhesion of a silicone-based sealant composition, a urethane-based sealant composition, and an acrylic-based sealant composition to various substrates such as concrete, EPDM rubber, glass, polyvinylidene fluoride (available as Kynar® PVDF resin from ATOFINA Chemicals, Philadelphia, PA), and polyvinyl chloride. In each sealant study, five substrates were used and each was
15 cleaned: glass with isopropanol/water, PVC with n-hexane, EPDM with toluene, Kynar® with acetone. (Solvent was applied and wiped off.) Concrete was cleaned by brushing under running water.

Adhesion was examined under the following conditions: (1) dry; (2) after 7 days immersion in water at 50°C; and (3) after 17 days immersion in water at 50°C. The
20 sealant compositions were investigated according to the following protocol: (1) "control" indicates that no adhesion promoter in accordance with the invention was added to the conventionally known sealant; (2) "primed" indicates that the substrate was primed (or coated) with a liquid adhesion promoter system ("APS") prior to application of the sealant (e.g., 85% APS, 15% 2-EH, e.g., RX-13928); (3) "resin on silica" indicates that the APS
25 was mixed with a silica support (e.g., RX-13946) and added to provide a sealant composition as a powder; (4) "resin only" indicates that a liquid APS (85% APS, 15% 2-EH, e.g., RX-13928) was added to provide the sealant composition; and, (5) "heat activated resin on silica" indicates that the APS on silica support (as above, e.g., RX-13946) was heated at 140°C for two minutes before addition to provide the sealant
30 composition.

In experiments where the substrate was treated with APS as a primer, the APS was applied with a cotton ball and wiped to remove excess of primer. The primer system (e.g., APS in 2-ethylhexanol) was allowed to dry at room temperature for 24 hrs prior to application of the sealant.

5 In experiments where the APS was added directly to the sealant, the mixing of the APS/2-ethylhexanol or APS/silica into the various sealants was accomplished using a double centrifugal mixer (Flacktek, Inc., North Carolina). 90 grams of the total mixture (sealant + APS) was used for each run and the 90 grams was mixed at least three times for about 30 seconds each time. In all such cases, the shear forces caused the sealant mixture
10 to become warm-to-hot. After mixing, the cap of the mixing container was removed and a plastic film was pushed down onto the sealant surface to protect it from moisture and air present in the head space. The cap was then placed back on the container and the mixture was allowed to equilibrate for at least one day before it was applied to a substrate.

The substrates were all one inch wide by three inches long. One end of each
15 substrate was covered with 3/4" wide Scotch® Tape to provide a non-adhered tab to pull and the sealant composition was applied as a smear approximately 1/8" thick over the entire length of the substrate. The sealant composition was allowed to cure under the conditions indicated in the data table and then tested for adhesion by pulling on the tab at a 90 degree angle to the surface. Only a fraction of an inch was pulled each time,
20 allowing several test measurements to be made from each sample. Adhesion was rated using a scale from 0 to 5, as described in more detail below.

According to the examples, the APS was added at about 2 wt.% active APS, except for the heat activated resin on silica, which was added at about 3 wt.% active APS. As used herein the term "active APS" indicates that the APS content has been adjusted for
25 solvent content and/or carrier (e.g., silica) content. For example, APS containing 15 wt.% solvent (e.g., RX-13928) was added at approximately $2.0/.85 = 2.35$ wt.%, based on weight of the sealant in the sealant composition.

The results demonstrate a significant improvement in the adhesion of the exemplified silicone-based, urethane-based, and acrylic-based sealant compositions to
30 various substrates, particularly to concrete after 17 days immersion in water at 50°C. The

results also demonstrate a significant improvement in the adhesion of the urethane-based sealant compositions to EPDM, glass, Kynar, and polyvinyl chloride substrates, particularly after 17 days immersion in water at 50°C.

5 The following legend should be used to interpret the data: 5 indicates cohesive failure; 4 indicates mixed adhesive/cohesive failure; 3 indicates strong adhesion but adhesive failure; 2 indicates moderate adhesion; 1 indicates weak adhesion; and, 0 indicates that the sealant composition nearly falls off of the substrate following curing.

The data is set forth in Table I, Examples 1-5, Table II, Examples 6-10, and Table II, Examples 11-15.

Table I

Sealant: Silicone sealant, amide cured															
Example	1			2			3			4			5		
Substrate:	Concrete substrate			EPDM substrate			Glass substrate			Kynar® substrate			PVC substrate		
	dry	7d wet	17d wet	dry	7d wet	17d wet	dry	7d wet	17d wet	dry	7d wet	17d wet	dry	7d wet	17d wet
control (sealant only)	5	5	4	5	5	5	5	5	5	3	5	5	5	5	5
primed	5	5	5	5	5	5	5	5	5	5	5	3	5	5	5
heat activated resin on SiO ₂ (silica)	5	no data	5	5	no data	5	5	no data	5	5	no data	5	5	no data	5

Table II

Sealant: Urethane sealant, diisocyanate cured															
Example	6			7			8			9			10		
Substrate:	concrete substrate			EPDM substrate			Glass substrate			Kynar® substrate			PVC substrate		
	dry	7d wet	17d wet	dry	7d wet	17d wet	dry	7d wet	17d wet	dry	7d wet	17d wet	dry	7d wet	17d wet
control (sealant only)	5	3+	3	1	3	5	5	2	3	2	2	4	2	2	3
primed	5	2	3	1	5	5	1	2	2	2	3	3	3	3	4
resin only	3	5	5	1	5	5	5	5	5	2	5	5	2	4	5
heat activated resin on SiO ₂ (silica)	3	no data	4	2	no data	3	5	no data	3	2	no data	2	2	no data	3

Table III

Sealant: Acrylic latex sealant															
Example	11			12			13			14			15		
Substrate:	concrete substrate			EPDM substrate			Glass substrate			Kynar® substrate			PVC substrate		
	dry	7d wet	17d wet	dry	7d wet	17d wet	dry	7d wet	17d wet	dry	7d wet	17d wet	dry	7d wet	17d wet
control (sealant only)	3	5	4	0-1	1	1	1-2	2	0	2	2	1	2	3	0
resin on SiO ₂ (silica)	5	5	4	0-1	1	1	0-1	1	0	1	1	1	0-1	0	0
resin only	5	5	5	0-1	1	1	1-2	no data	0	2	4	4	0-1	1	1
heat activated resin on SiO ₂ (silica)	5	no data	5	0-1	no data	1	1	no data	0	3	no data	1	0-1	no data	0

Table IV: Materials for Tables I-III

<u>Material</u>	<u>Chemical Description</u>	<u>Supplier</u>
Silicone sealant, amide cure	Calcium carbonate filled silicone sealant that cures with n-methylacetamide and n,n-diethylaminoethanol as the leaving groups; this system uses no catalyst	Dow Corning
Urethane sealant, diisocyanate cure	Typical urethane with polyetherbackbone polymeric system, a diisocyanate cure with calcium carbonate filler, plasticizer, and additives for UV protection and adhesion	Sonneborn
Acrylic latex sealant	Acrylic latex sealant, calcium carbonate filled	DAP
Cyrez® CRA-138M	Melamine Formaldehyde Resin	Cytec
RX-13928	RX-13804-42.5%, Resimene 3520, 42.5%, 2EH-15%	The C. P. Hall Company
RX-13946	Micro Cel E CSF 28%, RX13804, 36% Resimene 3520 36%	The C. P. Hall Company
RX-13845	Micro Cel E CSF 28%, RX13804, 36% Cyrez CRA138M 36%	The C. P. Hall Company
RX-13804	Di(2-ethylhexyl) dimerate (Empol 1016)	The C. P. Hall Company
Resimene 3520	methylated melamine, formaldehyde polymer	Solutia

The following Table V is a summary of the solvent solubilities of a representative adhesive resin, melamine (Resimene 3520) and a representative ester, RX-13804 (di-2-ethylhexyl dimerate) for use in selecting solvents capable of solubilizing both the ester and the resin in making a liquid solution of the adhesion promoter. The solubilities were only determined at 1:1 mixtures of solvent to dimerate/melamine. If both the samples were soluble in the solvent, the solutions were again mixed at a 1:1 ratio of dimerate + solvent to Melamine + solvent. The samples provide complete solubility of both dimerate ester and Melamine resin so long as the composition is at a 13% by weight or greater percent solvent level.

TABLE V

Melamine/Dimerate Solubilities				
Spot Checks				
Solvent		RX13804	Melamine	RX13804+Melamine
Xylene		S	S	S
1,4-Dioxane		S	S	S
Toluene		S	S	S
Acetonitrile		I	S	I
Ethanol		I	S	I
n-Hexanol		S	S	S
Ethyl Acetate		S	S	S
N,N-Dimethylformamide		I	S	I
n-Butanol		S	S	S
2-EH (2-ethylhexanol)		S	S	S
Methyl Ethyl Ketone		S	S	S
Methyl Isobutyl Ketone		S	S	S
Butyl Acetate		S	S	S
Chloroform		S	S	S
Carbon Tetrachloride		S	S	S
Hexane		S	I	I
Heptane		S	I	I
Isopropanol		S	S	S
Isodecyl alcohol		S	S	S
Isotridecyl alcohol		S	S	S
Ethylene glycol monobutyl ether		S	S	S
Dipropylene glycol monobutyl ether		S	S	S
S = Soluble; I = Insoluble				

TABLE V (Continued)					
Melamine/Dimerate Solubilities with 2-EH					
Quantitative					
Sample		% RX13804	% Melamine	% 2-EH	Appearance
1		42.5	42.5	15.0	Clear
2		43.0	43.0	14.0	Clear
3		43.2	43.2	13.6	Clear
4		43.3	43.3	13.4	Clear
5		43.5	43.5	13.0	Hazy (Insoluble)

In order to homogeneously emulsify the ester and/or the resin components of the adhesion promoter in a water-based carrier, any suitable emulsifying/dispersing agents can be used that are capable of forming a stable emulsion. Since the esters have a very low polarity and the resins have a very high polarity, if both the ester and resin are emulsified in a water-based carrier, generally a combination of emulsifying agents is needed to provide a homogeneous, stable emulsion in water. It has been found that the water-based emulsions should have a hydrophile/lipophile balance (HLB) in the range of about 4 to about 5 for best emulsification. Particular combinations of emulsifying agents found to be especially effective in providing a homogeneous, stable water-based emulsion of the dimerate esters and adhesive resin include a combination of an anionic metal stearate, *e.g.*, potassium stearate for the ester, and a non-ionic sorbitan oleate for the adhesive resin, as shown in the following emulsion preparation guide:

15	RX-13804	49	
	Stearic acid	0.2	} K Stearate
	KOH (45%)	0.1	
	Cyrez CRA-138M	48.7	
20	Span80 (sorbitan oleate)	(2 to 6 %) based on the weight of dimerate ester (RX-13804)	

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After adding Stearic acid, heat up to 90°C; add KOH slowly while mixing, mix for 5 minutes, then cool the mixture down to around 50°C. Then add Cyrez, then Span80.

Water-Based Emulsion Adhesion Promoter
RX-13937

Composition Component	% by wt.	Chemical	Supplier
RX-13804	49.0	Di-2-ethylhexyl dimerate	CP Hall
Stearic acid	0.2	tripled pressed Stearic acid	Witco
KOH (45%)	0.1	Potassium hydroxide 45%	Ashta
Cyrez CRA-138M	48.7	methyated melamine, formaldehyde polymer	Cytec
Span80	2.0	sorbitan monooleate	Uniqema

Solution-Based Adhesion Promoter
RX-13928

Composition Component	% by wt.	Chemical	Supplier
ester	42.5	Di-2-ethylhexyl dimerate	CP Hall
resin	42.5	methyated melamine formaldehyde resin	UCB
solvent	15.0	2-ethylhexanol	Sunoco